Spirit DataCine® Film Scanner

Not a dream but reality

THOMSON MULTI MEDIA
BROADCAST SOLUTIONS

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Introduction

Today's requirements for film scanning are now diverse and technically demanding. Digital television in its purest form is needed for standard definition and high definition (DTV) markets.
The demand for high resolution film data is increasing as the industry moves towards a resolution and format independent production environment.

To meet the demands of today, and more importantly those of tomorrow, Thomson multimedia has developed the world's first real time multi-format, multi-standard film scanner. The Spirit DataCine® film scanner - a totally new concept from Thomson offers unparalleled flexibility and image quality in a variety of television standards and film resolutions up to 2K.

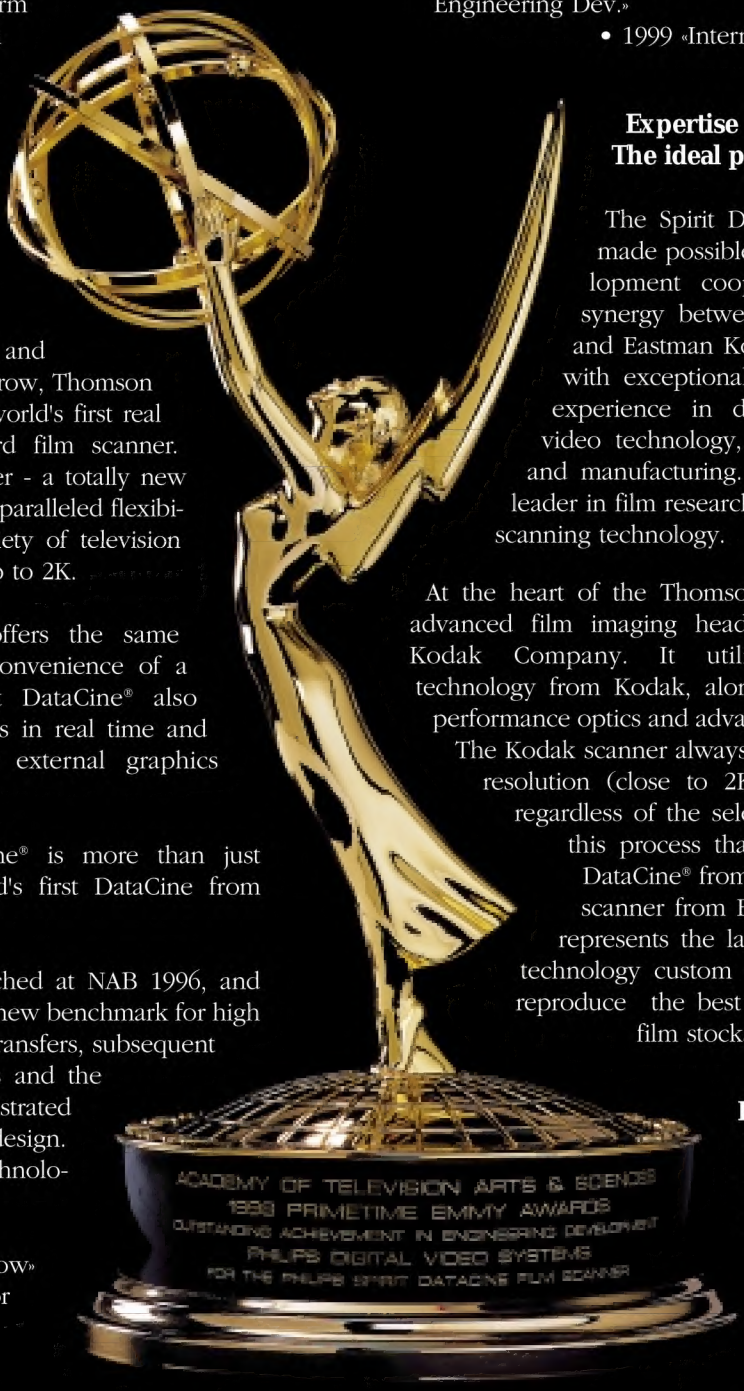
While the Spirit DataCine® offers the same operational functionality and convenience of a traditional telecine, the Spirit DataCine® also provides High Definition signals in real time and high speed Digital Data for external graphics workstations at film resolution.

That's why the Spirit DataCine® is more than just another telecine, it's the world's first DataCine from Thomson multimedia.

The Spirit DataCine® was launched at NAB 1996, and almost immediately became the new benchmark for high quality standard definition film transfers, subsequent additions of the HDTV options and the Data option has further demonstrated the flexibility of the basic design. Industry recognition for this technology has included:

- 1996 NAB «Editors' Pick of Show»
- 1996 ITS «International Monitor Award
- 1996 IBC «International Broadcasting Editors Award»

- 1997 Film and Video «1997 Most Valued Product»
- 1998 Academy of Television Arts and Science / Los Angeles «Primetime Emmy Award»
- 1998 The National Academy of Television Arts and Science «1997/1998 Outstanding Achievment in Engineering Dev.»
- 1999 «International Monitor Award»


ACADEMY OF TELEVISION ARTS & SCIENCES
1998 PRIMETIME EMMY AWARDS
OUTSTANDING ACHIEVEMENT IN ENGINEERING DEVELOPMENT
PHILIPS DIGITAL VIDEO SYSTEMS
FOR THE PHILIPS SPIRIT DATACINE FILM SCANNER

Expertise and global experience. The ideal partnership.

The Spirit DataCine® is a technology made possible through extensive development cooperation and a natural synergy between Thomson multimedia and Eastman Kodak Company. The one, with exceptional levels of expertise and experience in digital signal processing, video technology, plus mechanical design and manufacturing. And the other, a world leader in film research, manufacturing and film scanning technology.

At the heart of the Thomson Spirit DataCine® is an advanced film imaging head, designed by Eastman Kodak Company. It utilizes proprietary CCD technology from Kodak, along with customized high performance optics and advanced illumination control. The Kodak scanner always scans the film at a fixed resolution (close to 2K) in progressive mode, regardless of the selected output format. It is this process that differentiates the Spirit DataCine® from traditional telecines. The scanner from Eastman Kodak Company represents the latest in real time imaging technology custom engineered to accurately reproduce the best possible results from all film stocks and film types.

Fully digital high resolution signal processing

Throughout the Spirit DataCine® advanced high speed digital signal processing is used, which enables direct processing of 2K film data in real time while in still frame mode. All processing is performed on the 2K high resolution film data yielding

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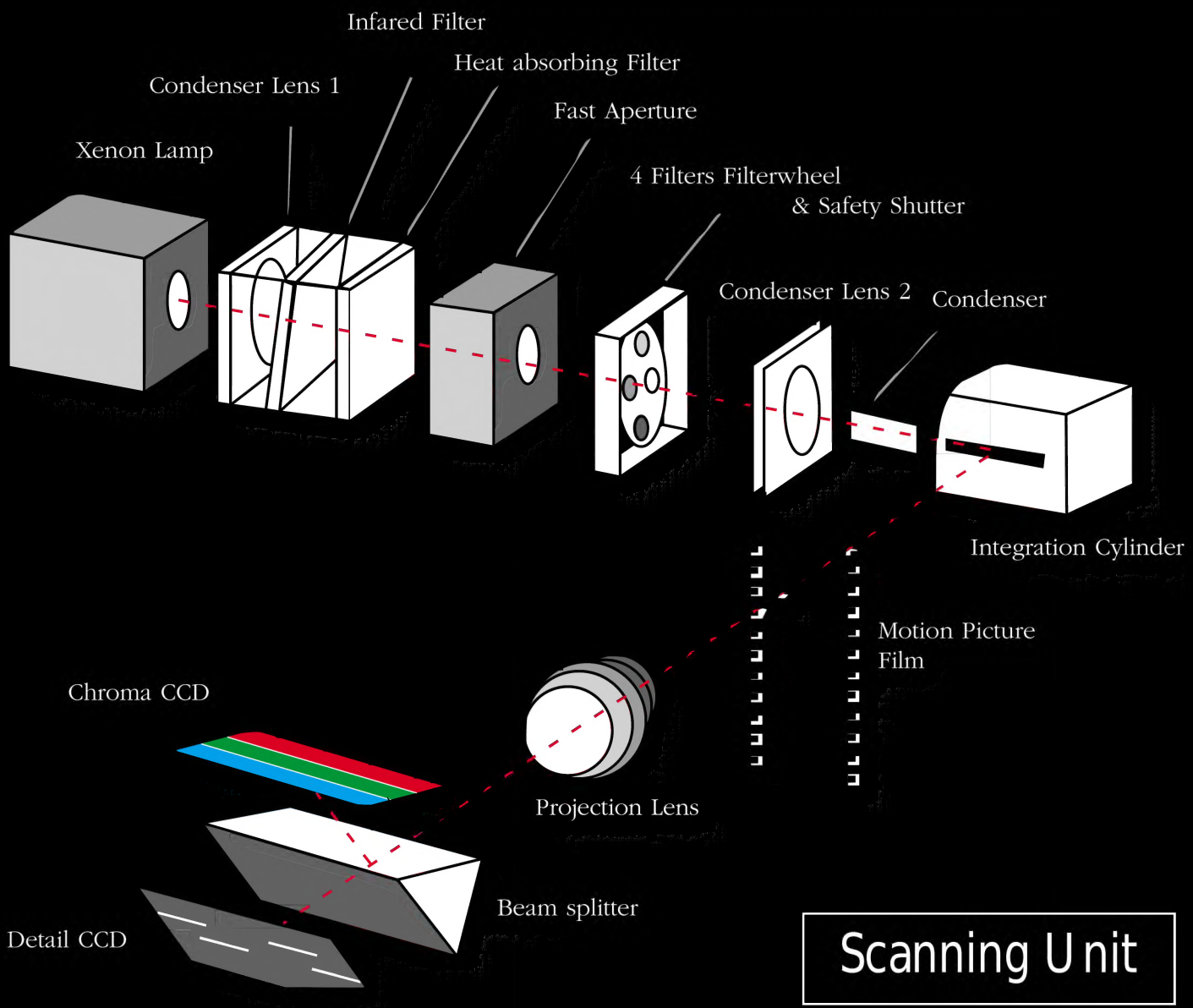
a data throughput of approximately 350Mbytes/sec. Because all signal processing is digital, no routine adjustments are required. Shading correction is fully automatic and the machine has no drift with guaranteed repeatability.
All these factors combine to deliver a very stable, repeatable, reliable film scanner that ensures a quality level which meets all of today's and tomorrow's high-end post production requirements.



Scanning Unit

NG TECHNIQUE

Color performance

Color performance

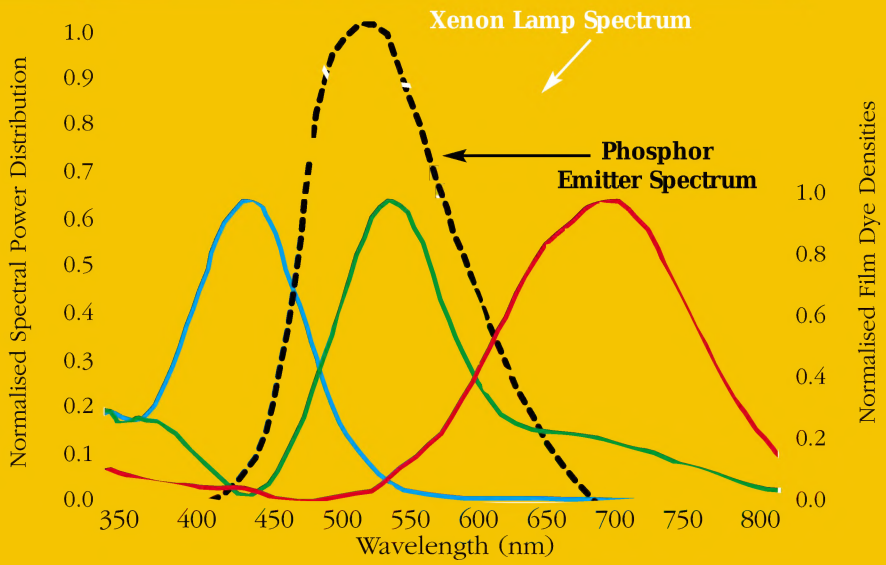
The key to color reproduction is the light source. The Spirit DataCine® uses long-life 300W short-arc Xenon lamp which provides a very pure white light source which covers the entire visible spectrum, including the short-wave blue area.
This contributes to the excellent signal-to-noise ratio in the blue channel. This also helps to compensate for the orange mask of color negative and intermediate film stocks. **Figure 1** shows the color spectrum of the Xenon lamp compared with the color density characteristics of the Kodak 5246 or 7246 negative material after the ECN-2 development process. Compared to the spectrum of the phosphors of CRTs used in flying spot scanners, the complete spectral area of the negative film is illuminated. The sensitivity characteristics of the RGB sensors used in the Spirit DataCine coincide with those of color density characteristics of the film.
The precise matching of the scanning system to the negative film material enables the reproduction of color not easily reproduced on a traditional CRT based telecine. There is also a very fine differentiation between colors. Relative to the number of ignition cycles, a Xenon lamp frequently achieves a lifetime in excess of 5000 hours. A failure during operation is very unlikely.

Advanced illumination system

- Long Life blue rich 300 W Xenon light source
- Illumination feedback control for very stable light level and color temperature
- Outstanding optical performance
- Filter wheel for optical matching of negative, positive, interpositive, and primetime film
- White light beam splitter - In place of traditional low efficiency color beam splitters
- Natural, pure colorimetry and a subtle color differentiation

Figure 1

Color Spectrums of Light Sources and Film Dyes



Spectral dye peaks are for Kodak 5246 / 7246, ECN-2 process
(source : Kodak Technical Data Sheet H-1-5246)

Six Sector Color Processor

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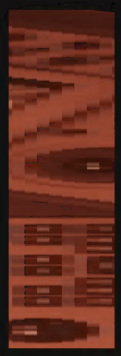


Application

Thomson film scanning solutions are provided with a standard primary Color corrector (RGB) which offers extensive range and latitude combined with precise digital control. This correction is real time and resolution-independent (up to 2K) so correction for any output format is supported, even data, with transparent switching between formats . There are applications where the basic primary functionality needs to be enhanced with basic secondary color control.

This option is a cost-effective solution designed to be used either alone with a controller or to enhance the features offered by third party color correctors that are today available on the market. Dailies, best light transfers and the growing adoption of downstream disk-based color correction systems means a high quality basic grade is required before the finishing touches are applied later in the process. Just like the Primary color correction system, the secondary color corrector is also real-time, resolution independent and working with the full film color space and at full film resolution-independent.

Six Sector Color Processor

Control

Operational control is provided via the popular controllers from DaVinci and Pandora. We also support full control from our graphical control panels supplied with the DataCine and Shadow Telecine products. No additional cables are required, all control functions are embedded within the existing IMCS Cheapernet control interface that is used on these products.

Features

The basic secondary color processor complements the primary color corrector already supplied with Thomson film scanners and vastly increases the functionality and flexibility of the basic Telecine system. Selected colors can be changed in luminance, saturation and hue across a wide range. The qualification of the selected color is defined by hue, and is split into the six applicable sectors, Red, Yellow, Green, Cyan, Blue and Magenta. To increase creative latitude we also refine the qualification of the color by adjustment of the position and width of each sector, a master saturation control is also provided.

A further very powerful feature within this option is a limiter and color legalizer. The limiter works in the luminance channel and can be switched between hard and soft clipping. The legalizer (that can be enabled or disabled at the users wish) works in the chrominance channel where problems with illegal colors may arise. The color tint (hue) is always maintained but the saturation is reduced in that particular picture element. This is an innovative way to maintain creative latitude and also ensure you are within legal color ranges, making possible the use of highly saturated colors without having to worry about illegal colors.

System

The Secondary Color processing option fits seamlessly within the internal processing and rack structure of the Spirit DataCine and Shadow Telecine.
Two cards are required for the Spirit DataCine, and one card for the Shadow Telecine. This option is available for any Spirit DataCine previously delivered.

Technology

The design and implementation is 100% digital integrating perfectly within our high-speed digital signal processing architecture, it employs up to 16-bit quantization and operates in real time at up to 2K resolutions.
Most important, when in unity mode complete transparency is afforded through the system.

DYNAMIC

Dynamic range

The Spirit DataCine® is unique in the adaptation of the basic photographic concept of exposure control. A fast response electro-mechanical aperture, placed directly in the optical path, enables the adjustment of the illumination level across 6 f-stops.
+/-3 f-stops adjustable within approximately one frame duration allowing real time density variation. This way, the amount of light saturating the film can be adjusted to allow the capture of the required dynamic range, regardless of the original film exposure. A conventional telecine has a low level fixed light source and electronic gain has to be used to compensate for exposure. This introduces more noise and seriously limits the dynamic range of the machine.

Sometimes film is exposed incorrectly by mistake, and sometimes intentionally for a desired effect. Regardless, the Spirit DataCine® offers un-compromised noise and artifact free performance to deliver maximum creative freedom to the user.

- **Fast aperture device allowing approximately +/- 3 f-stops variations within one frame duration**
- **14 bit deep film resolution primary color correction providing gain, gamma and lift controls**

RANGE

Optical performance

Both picture linearity and image geometry are important in any film transfer. The Spirit DataCine® offers perfect image geometry across the entire film frame, with no changes from still frame to any play speed, forward or reverse. This makes compositing easier, faster and far more accurate.

The Lens Gate assemblies and film gates can be exchanged quickly when required for the corresponding film gauge and format. The 35mm Lens Gate projects the full camera aperture width of Super 35mm film and the 16mm Lens Gate the full camera aperture width of Super 16mm film. The Film Gates for 35mm and 16mm film formats can be applied to enable 35mm academy or standard 16mm operation when required. The projection lenses are custom made by Eastman Kodak Company for this application and are very high performance multi-element assemblies (16 mm and 35 mm).
This contributes greatly to the filmic look, where the natural resolution from the film is produced by the optical system which requires little aperture correction.

The entire optical system is calibrated precisely to match the film material used. The spectral response of the light source, the optical matching filters, lenses, beam splitter and color interference filters embedded in the RGB CCD sensor are precisely matched for optimum density and color performance. All the optical components are custom made by Eastman Kodak Company specifically for use in the Spirit DataCine®. We use no "off the shelf" optical components which would have compromised overall performance.

- **Easily exchangeable lens gates**
- **Super 35mm and Super l6mm lens gate assemblies**
- **Academy 35mm and Standard l6mm adapters available for the Super Lens gates.**
- **High speed projector lenses - custom designed multi-element optics by Kodak**
- **High chromatic fidelity**
- **Remote, optical focus control**
- **Super 8mm gate (optional)**

For some creative applications – particularly in music videos, the grainy quality of Super 8mm film adds a very distinct atmosphere. But this look should not come at the cost of the other benefits of the Spirit DataCine® scanner, like image stability and consistency, precise colour control and a broad range of variable speed settings.

In response to this demand, Thomson Multimedia has now added Super 8mm capability. It has also recognised that Super 8mm scanning is likely to be an occasional requirement only for the typical facility, and so it has achieved this additional functionality in a package, which is cost-effective and does not in any way impair the functionality of the Spirit DataCine Scanner in 16mm and 35mm applications.

A new combined sprocket wheel capable of handling Super 8mm, 16mm and 35mm gauges replaces the existing sprocket wheel.
The second mechanical element is an adapter plate which mounts in the current Super 16mm gate to provide precise guidance of Super 8mm film.

The software with the option adds a separate preset for framing Super 8mm and modifies the zoom parameters to match the smaller image area. The transport characteristics are also modified for the lighter stock, allowing the same cores and film path to be used. Super 8mm can be scanned at precise film speeds between 4f/s and 57f/s.

OPTICAL PERFORMANCE

Diffuse illumination

Via a condenser lens, the light is focused and fed into an integration cylinder.
The light intensity in the integration cylinder is optically monitored and regulated to a constant level.
This ensures complete repeatability, across protracted periods of time.
Via the output slit, the light is then sprayed as a diffused light beam onto the film, which dramatically reduces the visibility of film base scratches and largely rendering superfluous a traditional messy wet gate operation. Traditional telecines use focused, collimated light to illuminate the film.
As it is illustrated in **Figure 2**, if the film base has a scratch present then the light is refracted by the film base generating a hard edged shadow - which appears as the scratch in the transfer.

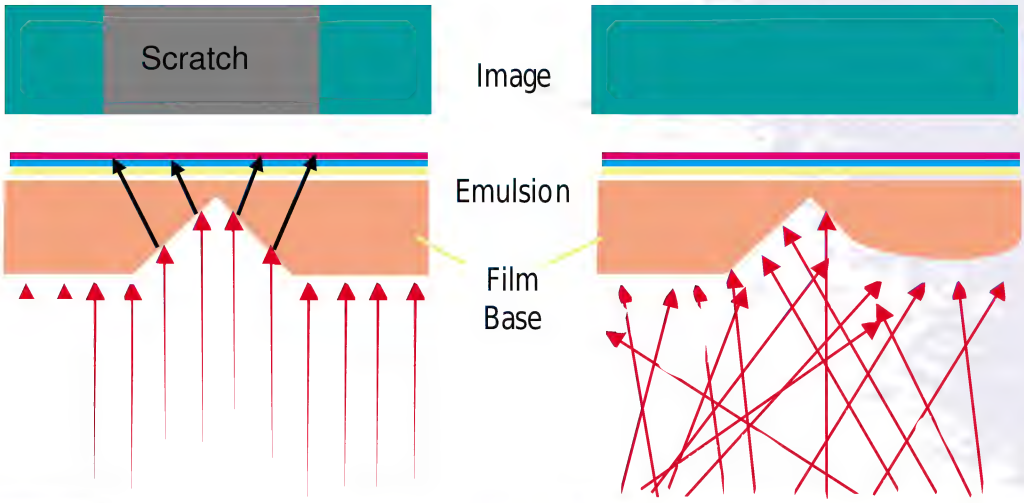
Diffuse illumination "sprays" diffuse light beams from all directions onto the film and although the beams are still refracted by the film base, no hard edges are apparent due to the multi-directional beams therefore optically masking the scratch. Wet gate systems used today achieve the same scratch concealment function with a chemical liquid, this fills in the scratch preventing beam refraction and therefore the shadow, this process is messy and risky as liquid leaks can cause damage to the sensitive electronics used in the telecine.

Advanced illumination system

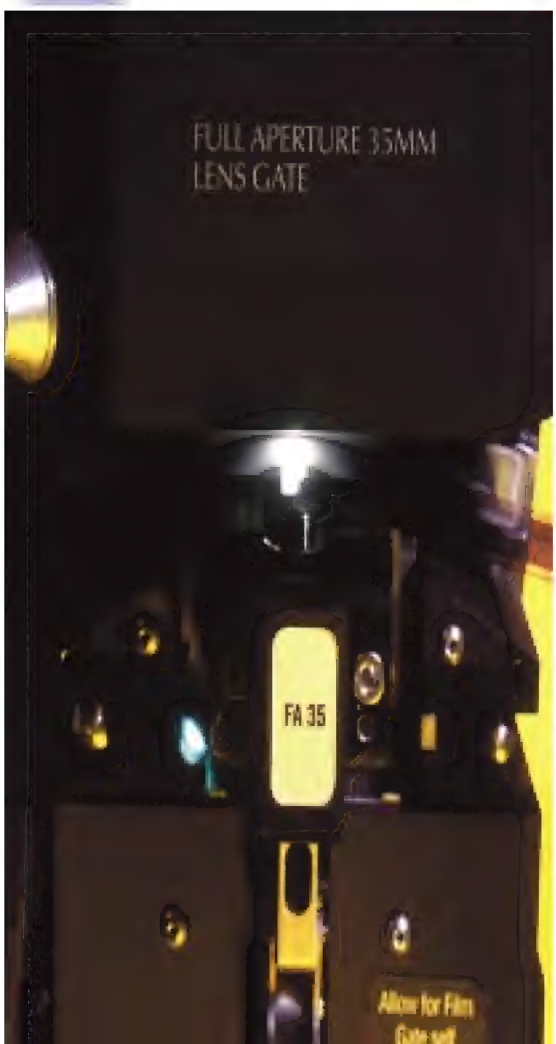
- Concealment of base film scratches
- Constant, even lambertian light distribution
- Regulated, repeatable light control

Figure 2

Collimated light versus Diffuse light



CRT Light = Collimated **Diffuse Light**



DIFFUSE ILLUMINATION

O V E

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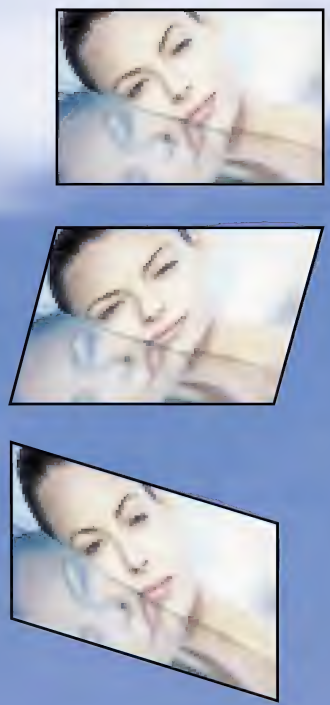
The Spirit DataCine® always scans the image, at 2K resolution, regardless of the output format selected. This has inherent benefits during the transfer process enabling greater color correction depth and latitude and the lack of aliasing artifacts in the image. A key component to this process is the real time spatial processing.

This facilitates the change of size (zoom), position (X.Y pan) and geometry (X,Y Lin) of the image including a full 360° rotation without aliasing, artifacts or loss of resolution. The image quality can be compared with an optical zoom and is achieved by subpixel processing at a resolution of 1/16 of a 2K pixel and by FIR filters with up to 32 taps. The architecture is a unique combination of two cascaded one dimensional filters as opposed to the traditional two dimensional filtering technique. This reduces the possibility of diagonal aliasing. The constant throughput for the spatial processor amounts to 7.2 Gigabits per second.

Since the zoom originates from a fixed high-resolution image, the effects of under scanning is avoided. These effects can be caused by flying spot scanners where the image size is adjusted by directly changing the scanning raster. As there is no variable optical pre-filtering the fine details will alias in the image.
The classic example is the car radiator grille which shimmers or beats objectionably.

A new Rhomboid effect has been added to the X & Y Zoom, X & Y linear and 360 rotation capabilities of the machine. These Rhomboid effects, which are included in the creativity package, allow the distortion of the image on two axis, as shown below.



R SAMPLING

Noise performance

Managing the noise level on the Spirit DataCine® was a key design goal. Achieving real time 2K scanning (about 350MBytes/sec.) and keeping the noise level below that of the film grain was the overall objective. This was achieved with a combination of optical design, sensor design and using all digital high speed signal processing. The CCD Sensors used in the Spirit DataCine® are custom made by Eastman Kodak Company. They are a line sensor design with a horizontal scan resolution of 1920 photosites for the detail sensor and 3x960 photosites for the color sensor.

The detail sensor is constructed as 4 linear sub-arrays of 480 photosites each, all located on a single chip. This design facilitates the parallel transfer of information, increasing bandwidth in order to use lower clock rates therefore lower clock noise and highly efficient charge transfer. The light which projected onto the detail sensor is panchromatic (white), thus all picture details are captured regardless of location in the color spectrum. The color sensor chip carries color interference filters for red, green and blue. Behind the filters, there is one line array sensor for each color with 960 photosites. The color photosites are physically four times the area of the detail sensor photosites (**Figure 3**).

The separate detail / RGB scanning topology used in this scanner gives a significant noise advantage over standard RGB scanning. The large-area photosites of the color sensors generate high signal currents, thus increasing the signal-to-noise ratio.

Prior to its combination with the color signal, the detail signal is filtered via a digital high pass filter and does not add significant noise.

This is illustrated in **Figure 4** which shows the inherent noise of the scanner, the noise at a 12-bit quantization and the film grain noise compared to transmittance.

Another important factor to consider is image flare. A CRT telecine is a frame based scanning system, where one of the disadvantages is flare artifacts. If an image has a very dense object on a light background there will be a slight optical halo seen around the dark object, a result of optical flare from frame based scanning. The narrow slit used for CCD scanning, and the diffuse light illumination system reduces greatly this flare effect resulting in significantly cleaner images.

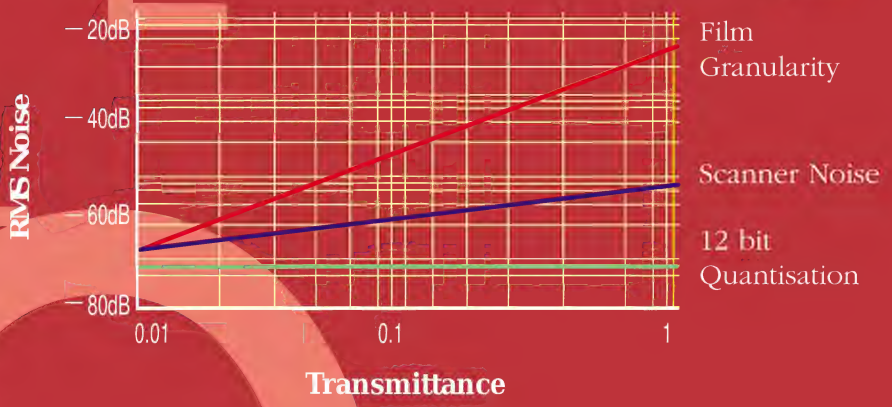
Proprietary imaging head

- Utilizes detail plus RGB concept to achieve signal-to-noise levels below the grain threshold of the film in all colors and at any output resolution
- CCD sensors are proprietary designs for the Spirit DataCine® manufactured by Eastman Kodak Company
- Single chip color sensor, featuring pre-registered tri-linear R.G.B. array with embedded color interference filters

NOISE PERFORMANCE

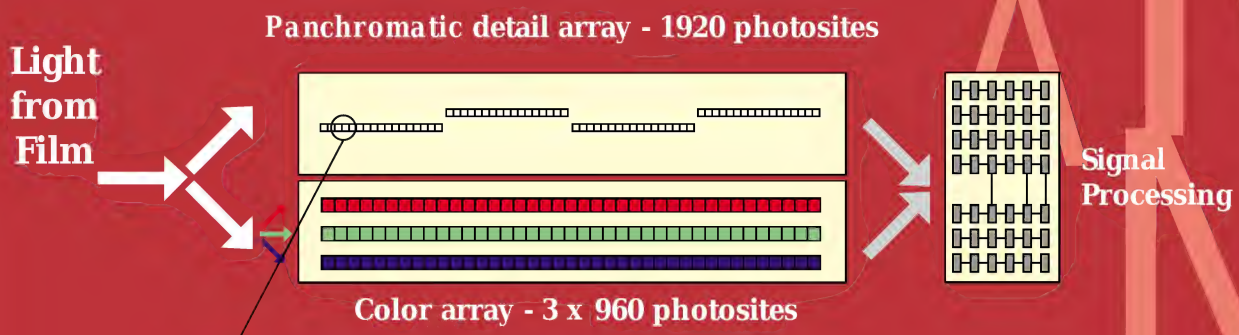
Signal to Noise Performance

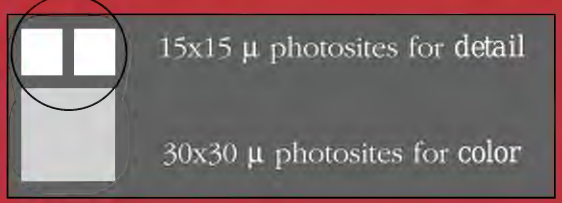
Figure 4



CCD Sensors

Figure 3





Color photosites are 4 times the area of the detail photosites for more efficient light gathering and low clocking speed

= Low noise for clean mattes

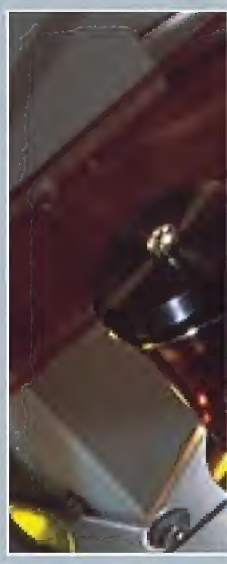
Image composition

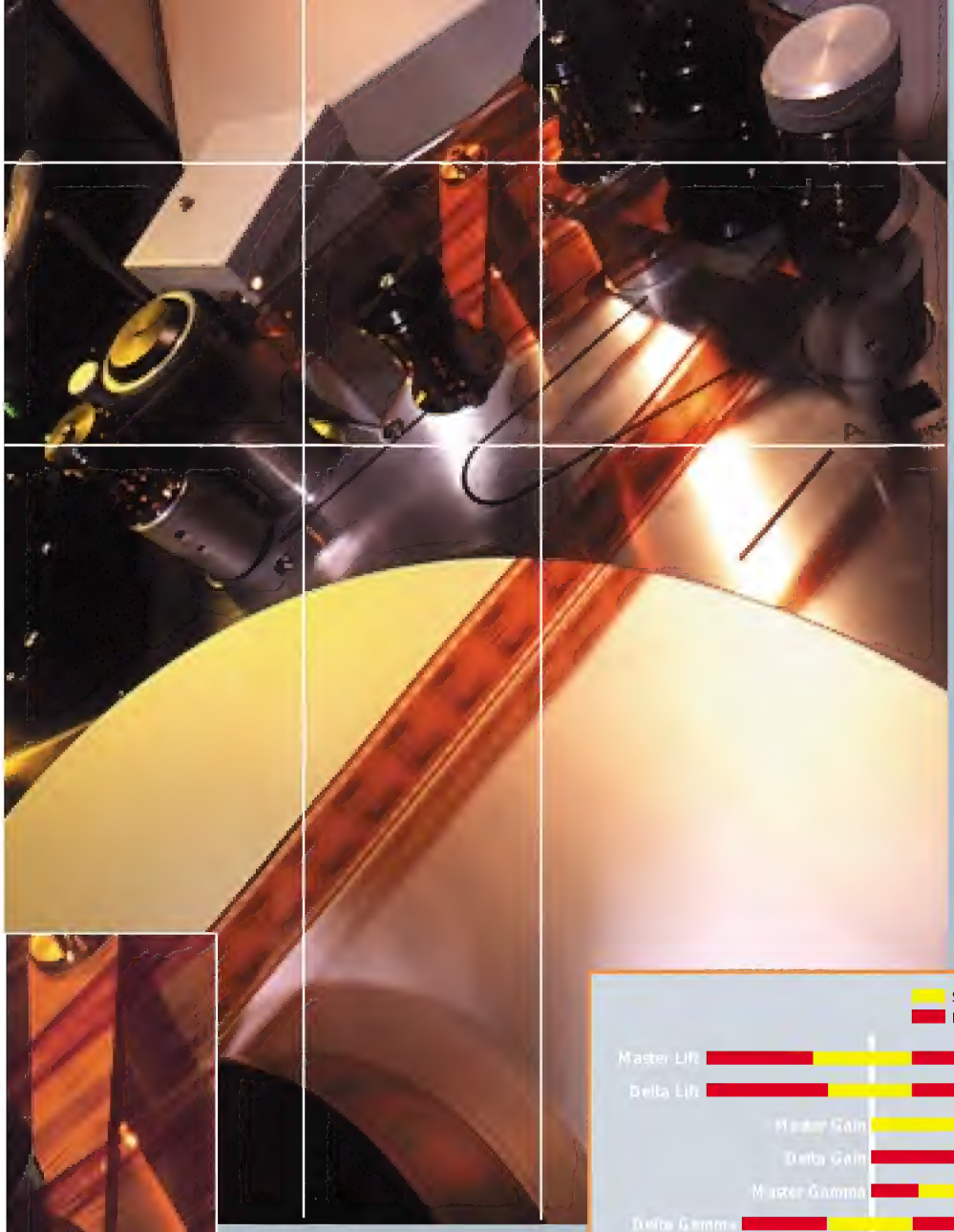
The Spirit DataCine® always scans at full resolution, and the user has total compositional freedom. Color correction is full bandwidth, with soft white clipping and extended knee functions in the blacks. Image manipulations (X,Y Zoom and Rotation) are processed in real time and at full resolution. The Spirit DataCine® also features a unique "sizing marker" mode of operation where the full scanned film frame is displayed and a set of extraction markers can be moved around the image to define the required area. The session can be programmed like this and when finally transferred the markers switch off and the effects are executed at full resolution and in full frame mode.
This is particularly useful for Pan Scan feature films. As the image manipulations are processed at full film resolution, there is no compromise on image quality or no limitation to the composition required, you are only limited by the original exposure on the film.

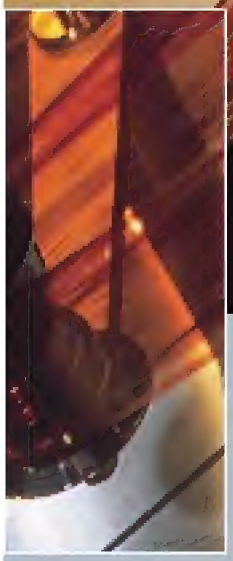
Aperture correction is provided with programmable settings for level and peaking as well as a coring adjustment to reduce the emphasis of any film grain. The aperture correction is always film relative and as the sizing (zoom) is after the aperture correction any interactive resolution artifacts are avoided.
For example, during a zoom operation on a CRT based telecine the scanning patch changes size, changing the spatial resolution of the image relative the static aperture correction applied. This produces some strange effects and can introduce un-predictable artifacts and high frequency alias as the zoom is executed.

Digital high resolution real time signal processing

- Internal 14 bit film resolution electronic test pattern generator
- 14 bit film resolution automatic shading and FPN correction
- Two 2K by 2K film data frame buffers, expandable up to a storage capacity of 34 frames using SIMM RAM modules
- 14 bit film resolution still frame color matching in gain and black as well as primary color correction providing gain, gamma and lift controls
- Film relative, film resolution aperture control with user adjustable peaking, leveling and coring
- Spatial data processing resulting in optical quality sizing and repositioning, including all pans and zooms - all adjustable and programmable in still frame mode
- Optional 360 degree image rotation
- Optional high speed HIPPI data interface for the transfer of film resolution images to workstations

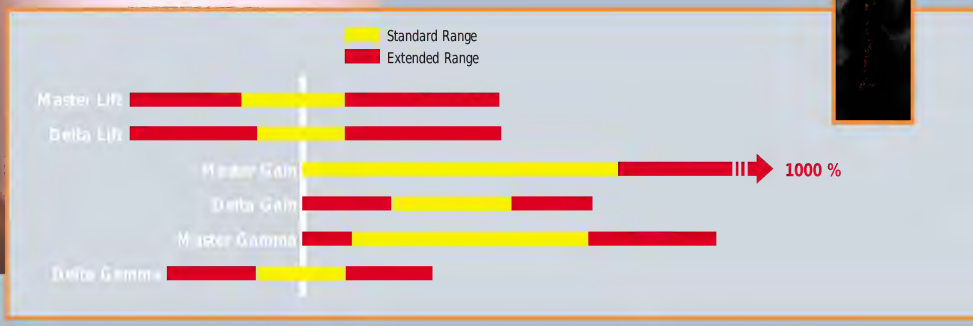






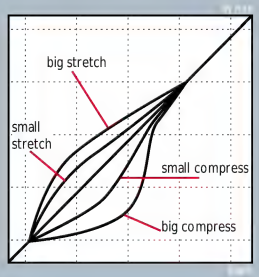
Creativity

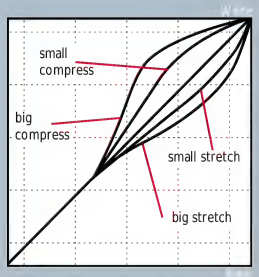
The Spirit DataCine is unique in that regardless of the output format selected the internal processing of the machine is always working at the full 2K resolution, with the full density range and color space of the film available for manipulation.
We have added a mode where "extended ranges" can be switched into the primary color processor, like a turbo boost to the ranges. The increase in range over the Standard Range is illustrated below.

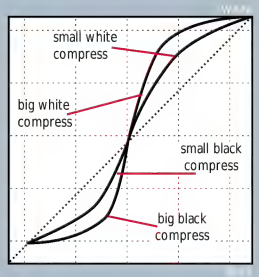


To this we have added the ability to select different "Toe" and "Shoulder" curves which can be applied to dramatically change the look of the machine for any given film type. The "print look" for negative transfers is now easy to replicate using the new black and white stretch and compression curves. The extended ranges make the correction of critical inter positive material (IP) far more precise and accurate.

This powerful processing is performed totally in the digital domain and is, therefore, free from any noise penalty regardless of how hard you push the machine.







SCANNING

Scanning speed

The 16-bit digital servo system, specially developed by Philips, handles 16mm and 35mm films gently and accurately over a very wide range of speeds. Coupled speeds (Select-a-Speed or Variable Speeds) can be adjusted from approx. 2 to 57 f/s with three-decimal-place accuracy. Full frame visual search is provided, and the shuttle speed can be adjusted up to 10 times normal running speed. All servo functions including the capstan, drive reels and tension arms are continually monitored to ensure safe and gentle handling of the film at all times. The film tension is approximately half that of traditional telecine systems greatly reducing stress on the film. The machine can handle film loads up to 1200m safely.

As the Spirit DataCine® uses horizontal line array CCDs, the frame can only be built if the film is moved across the scanning slit. Vertical composition is made by constant film movement. This is done by means of a capstan pulling film through the film gate. The transport is continuous motion driven by static friction from the capstan motor. No pins or mechanical obtrusions are used resulting in a very safe smooth film transport system.

Steadiscan (Option)

The basic stability of the machine delivers images close to today's non real time mechanical pin registration systems.
For the more critical applications for film to data to film transfers, where greater accuracy is required, a new corrective stability option called Steadiscan has been developed.

Steadiscan is an electronic passive system, no pins or additional mechanical parts are brought into contact with the film, making it very safe for the film and with an operational speed of 6.25 f/s a lot faster than current mechanical systems.
The process uses a high resolution camera to image the sprockets on 35mm negative film. The system measures any deviation of the sprocket hole precisely and automatically corrects for vertical and horizontal instability prior to the image leaving the machine.

- **Very smooth film handling utilizing continuous motion capstan drive**
- **Very low film tension - about half that of conventional telecine machines - for a low film stress characteristic**
- **Automatic end-of-reel servo stops to prevent damage to the film when high speed winding is completed High capacity spools - up to 1200m 16 bit integrated capstan and spooling servo control**
- **High performance basic stability, both horizontal and vertical**
- **Selectable Speeds of 2 to 57 frames per second, forward and reverse**
- **Full frame, correctly orientated image in high speed shuttle mode - forward and reverse**
- **High resolution, precision capstan and sprocket tachometers**

SPEED

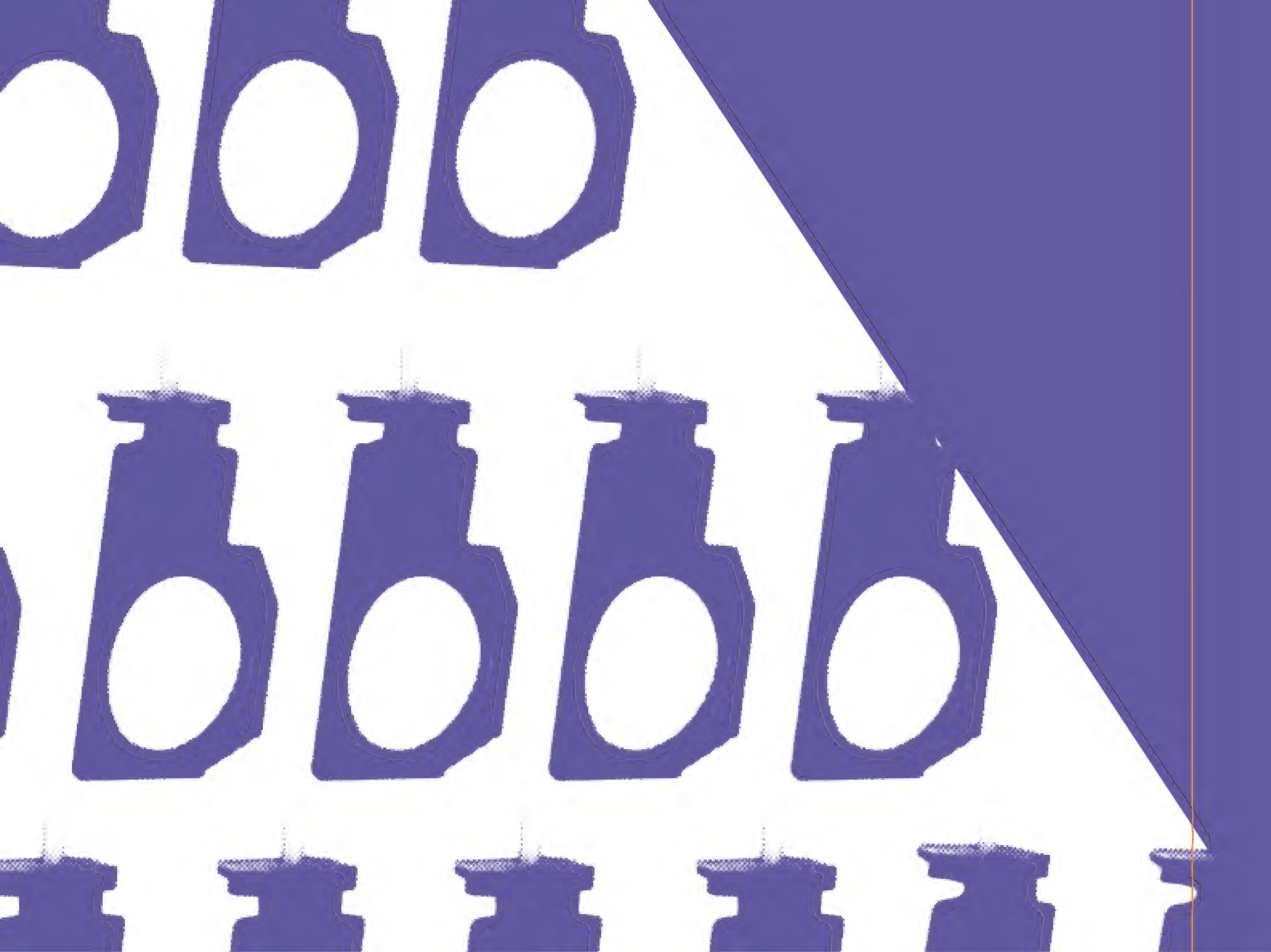
SPEED

Optical filtration

A custom designed filtration system is supplied with the Spirit DataCine®, allowing more creative freedom in the transfer process. A complete kit of optical diffusion filters is supplied and can be inserted using a special holder during the scan process.

The degree of diffusion required is selectable via a set of black and white supermist filters (supplied).

- **Special scan effects with custom-built optical filters**
- **Empty frames supplied for custom filters and nets**
- **Easy to use: each filter is supplied and protected in its own holder**
- **Visual indication, when filter is inserted**



Graphical Control Panel

Application

Much more than just a local control panel, the GCP is an innovative and flexible way to control the Thomson range of film imaging products : Spirit DataCine, Shadow Telecine and Specter Virtual DataCine as well as Scream and Steadiscan.

description

While in creative telecine applications a third-party controller is essential, there are a number of situations which do not need those advanced features. In these circumstances it makes sense to release the expensive Telecine controller and colour processor hardware for other work and use a more simple local control panel.

The GCP is revolutionary in telecine design in that it provides full access to all of the internal functionality of the Spirit DataCine, Specter Virtual DataCine or Shadow Telecine, including the internal primary and 6-sector color processing as well as Scream and SteadiScan. This is done via a simple but powerful graphical user interface. A carefully designed combination of a large colour TFT touch screen, soft key controls and digital potentiometers give both flexibility and speed of use. For test and alignment, the GCP gives the engineer access to all functions of the system, without the need to use a third party controller.

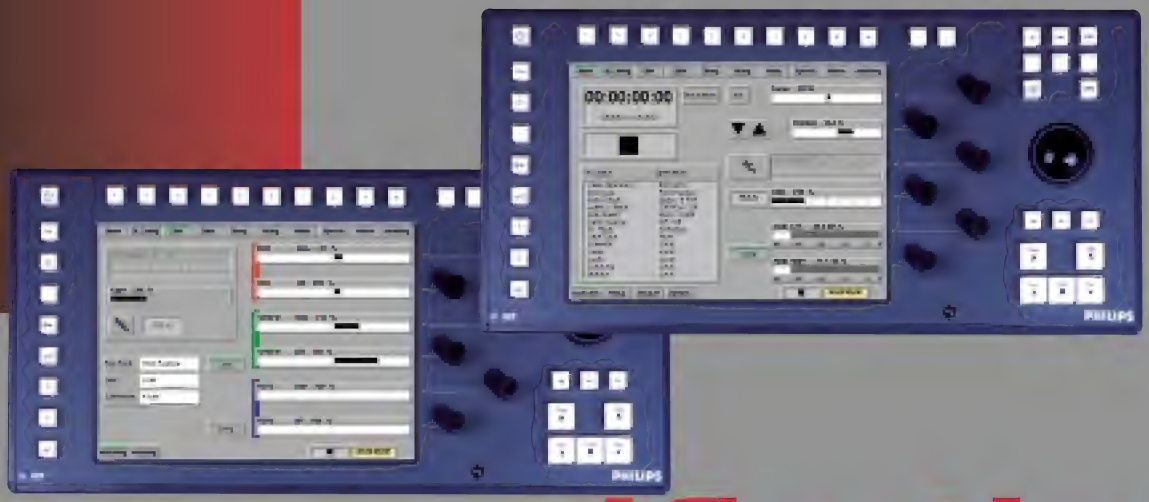
Colorists can also use it to explore the capabilities of the system, with junior staff learning the fundamentals of telecine control.

It could even provide all the control you need for some dailies and long form work.

Because the GCP is software based and driven through on-screen menus and soft keys, it can easily adapt as new facilities and features are added to the host system - Spirit DataCine, Specter Virtual DataCine or Shadow Telecine – and will continue to develop as new products are added to the Thomson Digital Film Applications portfolio.

Physically, it is a direct replacement for the original functional control panel, or it can be desk mounted or rack mounted depending on the application.

An upgrade programme is available for users of the functional control panel who wish to use the new GCP.



specification

- microprocessor-based architecture
- TFT colour display with touch screen
- 6 assignable digital potentiometers
- 1 trackball
- 37 assignable hard keys
- internal power supply
- no fan required
- same footprint as FCP
- trade-in upgrade programme for FCP
- simple 19" rack mount included

optional table mount with swivel frame available

optional 19" rack mount with swivel frame available

When to use a Spirit DataCine®?

The Spirit DataCine® is a very flexible machine, and can be used for almost any application in modern Post Production facility, applications include:

- Short form commercial post production
- Long form feature film mastering and DVD mastering
- Documentaries and episodic production work
- HDTV film mastering
- Film to film effects, using 2K data
- Archival and restoration.

The world is changing, digital television will soon dominate the broadcast and cable distribution channels, (as well as consumermedia e.g DVD) with digital television comes the requirement for compression, high levels of compression. To ensure artifact free compression and to achieve the best possible image quality using the least amount of transmission bits, certain image qualities are required.

- No electronic noise must be present
- The transfer must be very stable
- High frequency alias component should be minimized

The Spirit DataCine® was designed for the new digital era, and performs to the highest possible standards ensuring the best possible quality after any downstream MPEG compression.

More and more film based visual effects are required for feature film production. The Spirit DataCine® can deliver 2K film scans at 6 frames per second compared to many seconds per frame on conventional scanners. We can also deliver the files formatted and color corrected prior to the animation process for faster overall production.

IF ABSOLUTE PREMIUM QUALITY IS DESIRED.

Cost of Ownership and Customer Support

The Spirit DataCine® was designed to be a virtually maintenance free film transfer machine. There are no routine engineering adjustments required for day to day use. Consumable parts on the machine have a minimal cost and have a relatively long life. The projection lamp, which may last in excess of 5000 hours, can be purchased in quantity and stocked in the facility for fast exchange if required.

Lamp exchange is a simple task, no adjustments are required and the system is self calibrating. Other parts such as the capstan motor puck can be replaced without having to change the entire capstan motor assembly. This is convenient, in-expensive and very fast to change should the need arise.

These factors combined with the exceptional reliability record to date with minimal downtime results in a extremely low cost of ownership and very high utilization for the end user.

When a failure does occur, Thomson offers exceptional customer support, with distributed spares kits across many of our worldwide service centers. We also offer a number of customer care programs and service contracts for the support of the machine if required, these are available in a number of various coverage packages and configurations to suit your specific operational needs. Please ask your Thomson sales representative for details on the service plans available.

Spirit DataCine®
Film Scanner

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